Enamel Surface Roughness after Orthodontic Bracket Debonding and Composite Resin Removal by Two Types of Burs

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Abstract

Objective: Increased enamel surface roughness following orthodontic bracket debonding leads to increased plaque accumulation and enamel decalcification. Therefore, different methods are employed to achieve smoother enamel surfaces after bracket debonding. This study compared enamel surface roughness following orthodontic bracket debonding and composite resin removal using white stone and tungsten carbide burs.

Methods: In this in-vitro, experimental study, 20 first and second premolars of 10-20 year-olds were collected and their crowns were mounted in acrylic blocks. Roughness of the buccal surfaces of teeth was determined by atomic force microscopy (AFM) and the brackets were bonded to the teeth. After bracket debonding, composite remnants were removed using white stone and tungsten carbide burs. Parameters of enamel surface roughness were determined by AFM and time required for composite removal was also calculated. Repeated measures ANOVA was used to assess the changes in parameters based on the time of measurement, type of bur and their interaction effect. Time required for composite resin removal by bur was analyzed using one-way ANOVA and Tukey's multiple comparisons.

Results: Resin removal increased enamel surface roughness compared to the baseline values in all groups. However, no significant differences were noted between the two types of burs regarding arithmetic average of the roughness profile (Ra), the root mean square roughness (Rq) and the maximum peak-to-valley height in the sampling length (Rt) after resin removal. Time required for resin removal with tungsten carbide bur (34.2 seconds) was significantly shorter than with white stone bur (56.6 seconds)(both *ps*<0.0001).

Conclusion: Considering the similar enamel surface roughness values achieved by the two burs, tungsten carbide burs are recommended for resin removal following orthodontic bracket debonding.

Key words: Atomic force microscopy, Composite resin, Debonding, Enamel, Orthodontic bracket, Tungsten carbide bur, White Stone bur.

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Introduction:

Orthodontic bracket debonding and removal of composite remnants from the teeth surfaces following termination of orthodontic treatment must be performed in such a way that the enamel surfaces return to their pretreatment state (1). Adhesive remnants on the enamel surfaces must be removed after bracket debonding. However, methods employed for adhesive remnant removal may scratch the enamel surface or produce craters or grooves (2, 3). Thus, it is extremely important to remove brackets without traumatizing the enamel surface (4).

Researchers have used several methods for safe resin removal and polishing of enamel surfaces including the use of scalers, pliers, tungsten carbide burs with hand piece or different polishing discs (1, 4-6). Ultrasonic devices and air-abrasion with aluminum oxide particles are alternative methods for adhesive removal (7,8). On the other hand, low-level laser irradiation can eliminate composite remnants on the enamel surfaces as well. Also, by applying small loads during bracket removal, composite remnants may be removed (9).

An efficient method for removal of composite remnants is the use of an appropriate bur along with the polishing discs and a proper polishing paste (10). If after adhesive removal the enamel surfaces are intact, use of pumice or prophylactic paste will not be necessary. However, in most cases, adhesive remnants are seen on the enamel surfaces even after cleaning and polishing with rotary instruments (11).

With advances in techniques and instruments, different burs have been introduced and variable efficacy in resin removal. White stone burs are among the commonly used burs for resin removal. These burs are available in the Iranian dental market and studies have reported controversial results regarding their effects on enamel following resin removal (12, 13).

Enamel surface roughness is often assessed by scanning electron microscopy (SEM), which is subjective and non-reproducible. Quantitative assessment of surface roughness is not feasible via SEM. Thus, SEM cannot be used for comparison of surface roughness following the use of different techniques for resin removal (14). Atomic force microscopy is an alternative to SEM and captures multiple high-resolution topographical scans for assessment of surfaces with nano-scale irregularities (15, 16). Other advantages of AFM include the need for minimal preparation of specimens, the ability to simultaneously capture 2D and 3D images and enabling re-assessment of specimens (17, 18).Despite these differences, SEM and AFM are somehow similar. They both probe the surface features to generate an image of it. Also, they are similar in lateral resolution, which serves as a scale.

This study aimed to compare enamel surface roughness after orthodontic bracket debonding and composite removal by white stone and tungsten carbide burs.

Methods:

This laboratory experimental study was conducted on 20 sound first and second premolars extracted for orthodontic reasons. Patients were between 10-20 years old and presented to the Orthodontics Department of Shahid Beheshti University, School of dentistry. All the teeth had intact buccal surfaces with no caries or cracks and had no history of exposure to chemicals. The teeth were stored in isotonic solution prior to preparation. They were transferred to the laboratory in plastic bags to prevent surface contamination. In the laboratory, the teeth were mounted in transparent acrylic resin and stored in isotonic saline solution. Surface roughness of specimens was primarily measured using NanoWizard®AFM (JPK Instruments, Berlin, Germany). The teeth were etched with 37% phosphoric acid gel for 30 seconds, rinsed with water and air-dried. Brackets were bonded to the teeth surfaces using No-Mix bonding adhesive (3M, Unitek, Monrovia, CA, USA). Pressure was applied and the excess material was removed by the tip of an explorer. Specimens were then immersed in water for 24 hours. Next, orthodontic brackets were debonded using a fine cutter and the teeth surfaces were cleaned of resin remnants with bur. For bracket debonding, they were held from the mesial and distal and the peeling load was applied to minimize enamel traumatization. In the next step, the teeth were randomly prepared by white stone (Arkansas 661 DEF, D&Z, Germany)(Figure 1) or 12-flute tungsten carbide burs (0197 D&Z, Germany) alternately (Figure 2). The specimens were then subjected again to AFM. Therefore, the specimens were subjected to AFM twice: before bonding and after bonding and debonding.

Figure 1- White stone bur (Arkansas 661 DEF, D&Z, Germany)

Figure 2- Twelve-flute tungsten carbide bur (0197 D&Z, Germany)

The surface roughness of specimens before and after preparation was evaluated using AFM (Figure 3). AFM topographic images of the selected areas were recorded in contact mode. The device is equipped with a scanning probe with maximum range of 100×100×5µm in xyz dimensions. For measurement of surface roughness, the tip of the probe is dragged across the surface of specimens and images are captured from the middle one-third of the buccal surfaces. Of each specimen, two to three images (20×20µm) were obtained before bonding and similarly two to three images were obtained after debonding. Next, for each specimen, five images (5x5µm) were selected from the primary images by blind randomization in such a way that the images were noise-free. The coordinates of three points on the surface were determined at the center of specimen.

Figure 3- Atomic force microscope (NanoWizard II®)

For statistical analysis, the mean values were calculated. Three parameters related to surface roughness were determined (in nanometer) namely Ra (arithmetic average of the roughness profile), Rq (the root mean square roughness) and Rt (the maximum peak-to-valley height in the sampling length).

All steps of bonding, debonding and resin removal were done by the same operator on teeth surfaces and each preparation for each tooth was performed by a new bur to eliminate the effect of used bur on the results. Complete removal of resin remnants was ensured clinically by observation of specimens under a magnification loupe. The time required for complete resin removal from enamel surfaces was calculated in seconds.

Repeated measures ANOVA was used to assess changes in parameters based on the time of measurement, type of bur and their interaction effect. One-way ANOVA was used to assess the difference in surface roughness parameters and the time required for complete removal of resin remnants by bur. Since the results of one-way ANOVA were significant, Tukey's multiple comparisons test was applied for pairwise comparison of groups with regard to the time required for complete removal of resin remnants.

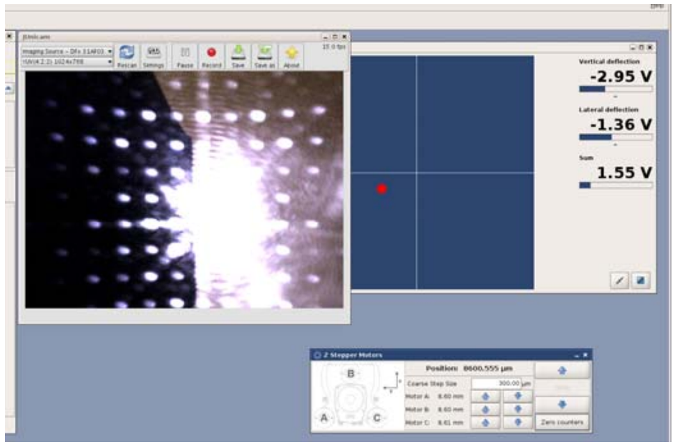

Figure 4- Adjustment of laser and cantilever in AFM

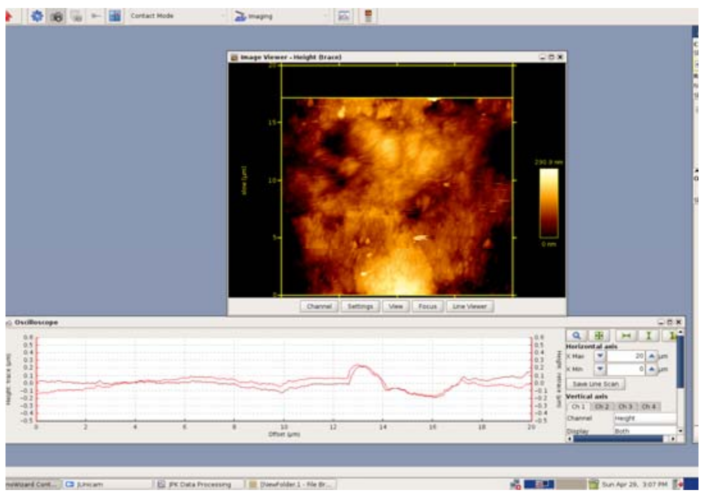

Figure 5- Capturing an image from the buccal enamel surface

Results:

The mean time required for removal of resin remnants by tungsten carbide bur is shown in Table 1. One-way ANOVA showed a significant difference between the two groups with regard to the time required for removal of resin remnants ($p<0.001$). Moreover, Tukey's pairwise comparisons revealed that the time required for complete removal of resin remnants was significantly shorter by tungsten carbide bur compared to white stone bur (Table 1).

Table 1-The mean time required for complete removal of adhesive remnants using white stone and tungsten carbide burs (under a magnification loupe)

Method	Mean	Standard deviation	95% confidence interval of mean		Minimum	Maximum
			Lower boundary	Upper boundary		
White stone bur	56.5	10.66	48.98	64.22	42.0	79.0
Tungsten carbide bur	34.2	5.12	30.54	37.86	26.0	40.0

The mean Ra value was 18.59 (13.13) nm before resin removal by tungsten carbide bur. This value after composite resin removal was 44.92 (14.71) nm. The mean Ra value was 22.56 (12.41) nm before resin removal by white stone bur. This value after resin removal was 30.37(11.18) nm (Diagram 1).

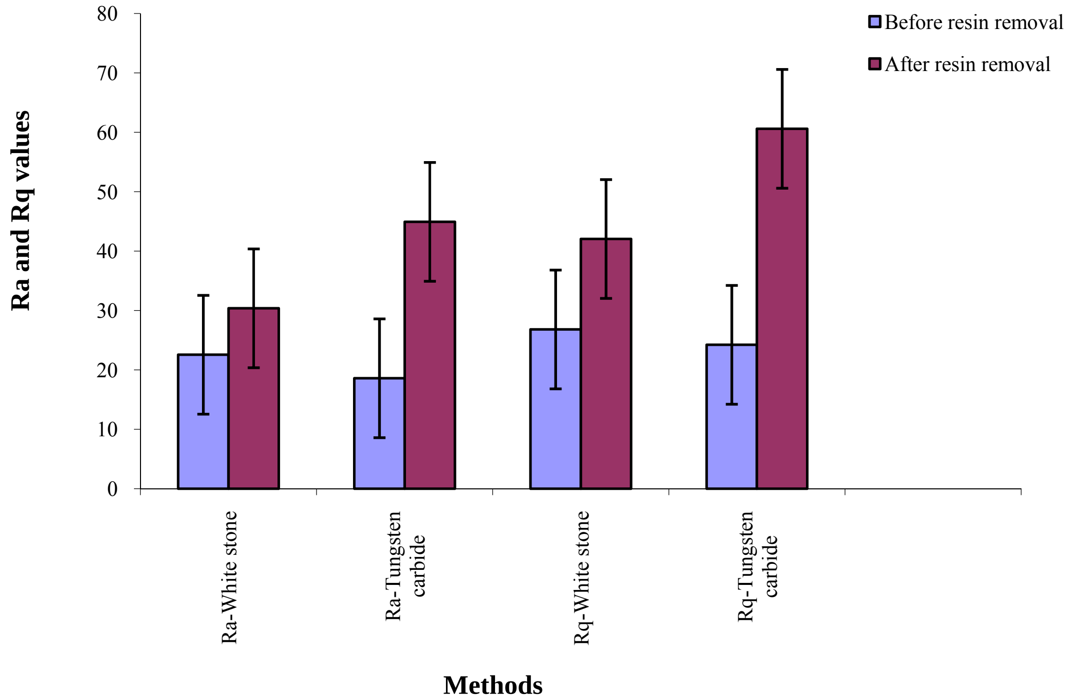

Diagram 1- The Ra (arithmetic average of the roughness profile) and Rq(the root mean square roughness) values before and after resin removal with white stone and tungsten carbide burs.

Repeated measures ANOVA showed that the Ra values significantly increased after resin removal in both methods ($p<0.001$). However, the interaction effect of time of measurement and method of adhesive remnant removal was not significant ($p=0.16$). Moreover, method of resin removal had no significant effect on the magnitude of increase in Ra values ($p=0.09$). In other words, tungsten carbide and white stone burs were not significantly different with respect to the Ra of the enamel surface after adhesive remnant removal.

Rq values were also calculated before and after resin removal with tungsten carbide and white stone burs. The Rq values were 26.81 (15.68) nm before and 42.04 (15.05) nm after resin removal with white stone bur (Diagram 1).

Based on the results of repeated measures ANOVA, the Rq value significantly increased after resin removal ($p<0.001$). However, the interaction effect of time of measurement and method of adhesive remnant removal was not significant ($p=0.13$). Moreover, method of resin removal had no significant effect on changes in Rq values ($p=0.14$). Thus, tungsten carbide and white stone burs were not significantly different with respect to the Rq of the enamel surface after adhesive remnant removal.

The Rt (the maximum peak-to-valley height in the sampling length) values before and after resin remnant removal with tungsten carbide and white stone burs are shown in Diagram 2.

Based on the results of ANOVA, Rt significantly increased after resin removal ($p<0.001$) and the interaction effect of time of measurement and method of resin removal was significant as well ($p<0.04$). However, method of resin removal had no significant effect on increase of Rt values ($p=0.29$), In other words, tungsten carbide and white stone burs were not significantly different with respect to the Rt of the enamel surface after resin remnant removal.

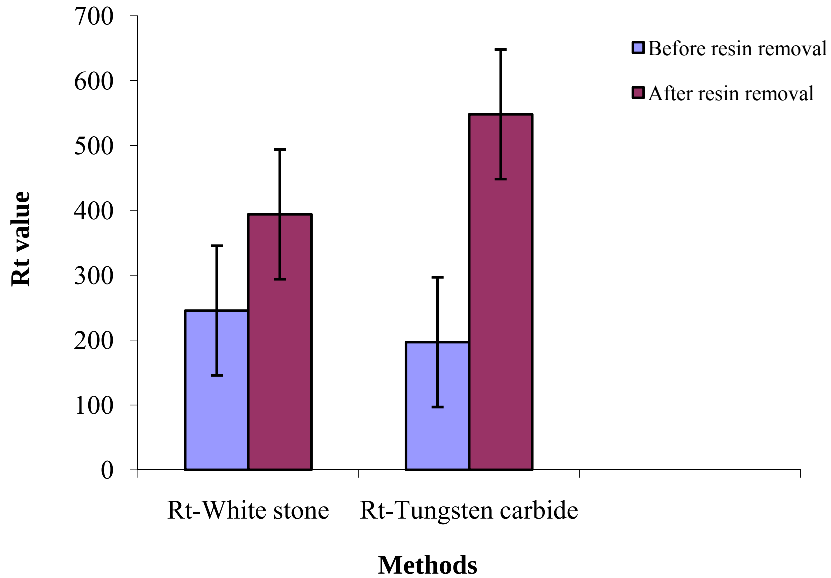

Diagram 2- The Rt (the maximum peak-to-valley height in the sampling length)values before and after resin removal with white stone and tungsten carbide burs

Discussion:

Resin removal in both groups increased enamel surface roughness compared to the baseline value. The two methods were not significantly different in terms of the roughness parameters. Although the surface roughness was similar after the two resin removal methods, time required for resin removal was significantly different between the two methods.

One reason for the lack of a significant difference between resin removal methods is the high standard deviation of surface roughness parameters. Due to the inverse correlation of standard deviation with the statistical results, the effects of the two methods were not significantly different with regard to enamel surface roughness.

Previous studies have mainly used SEM, visual observation of photographs and the adhesive remnant index for assessment of enamel surface roughness after termination of orthodontic treatment and bracket debonding (19-21). However, by using these techniques, enamel surface texture is not evaluated following resin removal.

In the current study, AFM was used for quantitative assessment of enamel structure and surface roughness. This method has been used in only a few studies. Most previous studies have used techniques with less precision than AFM; while AFM is an acceptable method for analysis of hard dental surfaces with small irregularities (16, 22). This method is non-invasive and requires minimal preparation of specimens. Moreover, in AFM, 2D and 3D images are simultaneously obtained and the specimens can be repeatedly evaluated, without being traumatized (16-18). In SEM, surface roughness of specimens cannot be quantitatively evaluated and the obtained results are completely subjective; thus, the examiners may have different perceptions and interpretations of them (23, 24). Thus, SEM analysis can only be used as an adjunct to quantitative calculations of surface roughness. Considering the use of quantitative analyses in the current study, we were capable of comparing the results of surface roughness testing following the use of different methods of resin removal.

On the other hand, enamel fragility depends on patient's age to some extent and aging changes the organic and mineral (especially fluoride) contents of the enamel. Thus, in the current study, extracted teeth of young patients were used since these teeth are more resistant to fracture or enamel cracks during extraction (25). Thus, sound first and second premolars of patients in the age range of 10 to 20 years presenting to the Orthodontics Department of School of Dentistry, Shahid Beheshti University of Medical Sciences were selected and evaluated.

In some previous studies, two parameters of enamel roughness have been evaluated after removal of composite remnants following orthodontic bracket debonding and only the Ra parameter has been reported as an indicator of surface roughness (26, 27). Whitehead *et al*. in 1999 showed that assessment of Ra parameter for evaluation of enamel surface roughness is not sufficient (28) because equal Ra values cannot guarantee equality of surface roughness and specimens with equal Ra values may have different surface roughness. Ra parameter cannot differentiate projections from depressions. To accurately determine the roughness profile, other factors related to surface roughness must be evaluated. Therefore, in the current study, Rq (the root mean square roughness) and Rt (the maximum peak-to-valley height in the sampling length) parameters were also calculated. Despite higher accuracy of findings due to the use of three surface roughness parameters, the results must be interpreted with caution because the characteristics of the needle used for measurement of surface roughness parameters are variable and the limitations of surface profilometry in this regard must also be taken into account (28). On the other hand, Wennerberg *et al.* (1999) emphasized that 2D calculations do not have the required efficacy for surface roughness measurement. A thorough description of enamel surface roughness must include all three parameters and transverse and longitudinal calculations (29). In the current study, the parameters of Ra, Rq and Rt were calculated as surface roughness parameters and their results were similar. The two methods of resin remnant removal by tungsten carbide and white stone burs were not significantly different in terms of these three parameters.

However, the two groups were significantly different with regard to the time required for resin removal. The mean time required for resin removal was 34.2 seconds with tungsten carbide and 56.6 seconds with white stone bur. Clearly, duration of procedure is very important in dentistry and even in case of superior therapeutic outcome, lengthy procedures are not acceptable to patients. Considering the equal efficacy and surface roughness values of the two methods and faster adhesive remnant removal by the tungsten carbide bur, this bur is recommended as an acceptable method for resin remnant removal following orthodontic bracket debonding.

At present, adhesives are mainly removed by tungsten carbide burs during the polishing steps. Brauchi *et al.* in 2011 compared enamel surface roughness following carbide bur preparation and air abrasion and found no significant difference in the enamel surface roughness between the two methods. Thus, they stated that both methods were equally effective (30).

The ability of burs for composite resin removal is related to several factors such as the idling speed of hand piece, pressure applied to the hand piece during surface preparation with bur, type of bur and the speed of water coolant spray directed at the bur-tooth interface (31, 32).

In a study by Ulosoy *et al.* in 2009, different carbide burs and polishing materials were compared for resin remnant removal from the tooth surfaces after orthodontic bracket debonding. Eighty human premolars were used. The fastest resin removal was achieved by 30-flute tungsten carbide burs while the smoothest surface was achieved by PoGo micro-polisher followed by Super-Snap Rainbow system (32).

Karen *et al.* in 2010 used tungsten carbide and fiber-reinforced composite burs for removal of resin remnants from the enamel surface following orthodontic bracket debonding. The two methods yielded significantly different surfaces in terms of surface roughness and the composite bur yielded a smoother surface compared to the baseline enamel surface roughness; however, requiring a long time for complete resin removal was the main drawback of this technique (33).

Ahrari *et al.* in 2013 compared enamel surface roughness following adhesive removal with different burs and Er:YAG laser and reported that the application of ultra-fine diamond bur or Er:YAG laser caused irreversible damage to enamel and application of these methods was not recommended for adhesive removal. In their study, low- and high-speed tungsten carbide burs yielded the lowest value of enamel surface roughness (34).

Tungsten carbide bur blades remove materials by flow-driven processes rather than by brittle fracture; thus, these burs are suitable for use in smooth and soft surfaces like that of resin.

Despite using AFM, which is a valid technique, and quantitative assessment of enamel surface roughness, it should be noted that the results were based on microscopic observations in a nanometer scale and no macroscopic evaluation was done. Use of different burs may yield macroscopically different surfaces (in terms of surface roughness); however, this issue was not evaluated in the current study.

The most ideal method for evaluation of enamel surface roughness is specifying a certain point on the buccal enamel surface and assessment of the same point in terms of surface roughness before and after bonding. Unfortunately, there is no way to specify a point on the tooth surface without demarking it. On the other hand, even the smallest marks on the surface increase the risk of change and errors in AFM results. Thus, we tried to overcome this problem by increasing the number of images (five images for each specimen). In other words, the boundaries of the middle one-third of the buccal surface were known to the examiners, but demarcation of a certain point measuring 100×100µ and observation of the same point after preparation was not feasible.

Conclusion:

Clinically, tungsten carbide burs yield a surface roughness similar to that achieved by white stone burs following adhesive remnant removal. Considering the long time required for resin removal by white stone burs and faster resin removal by tungsten carbide burs, the latter can be used for adhesive remnant removal following orthodontic bracket debonding. Considering the equal surface roughness following the use of tungsten carbide and white stone burs, shorter time required for resin removal by tungsten carbide bur and no need for expensive equipment, tungsten carbide burs are efficient enough for removal of adhesive remnants from the enamel surfaces following orthodontic bracket debonding.

Conflict of Interest: "None Declared"

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